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ABSTRACT

This study attempted to extend prior research on everyday problem solving by analyzing the effects of goal clarity and the presence or absence of a partner on performance in a number of problems. Subjects were 35 undergraduates who were screened, matched, and tested as singles or dyads during which time they thought aloud. Problems included mazes, Piagetian logical problems in abstract or everyday modes, a philosophical problem, and cryptarithmetic. Data were analyzed using t-tests and analyses of variance. The results revealed that performance on some problems was influenced by partner status, and that respondents' performance varied across the problem set. The hypothesis that goal clarity would be associated with better performance was supported among the logical problems but not for the maze problems. The hypothesis that Piagetian logical problems would appear more difficult the more interpersonal/everyday and the less abstract the context, was supported. Tests of the hypotheses concerning style of problem solving have not been completed. Results are discussed in terms of cognition and information processing theory. Applications are made to lifespan development and to clinical problems. (Author/NB)

Effect of Goal Clarity and Presence of A Partner on Problem Solving Performance[1]

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Brief Report

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Runninghead: Factors in Problem Solving

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Abstract

The everyday problem solving research of the author was extended by analyzing the effects of goal clarity and the presence or absence of a partner on performance in a number of problems. Undergraduates were screened, matched and tested as singles or dyads during which time they thought aloud. Problems included mazes, Piagetian logical problems in abstract or everyday modes, a philosophical problem , and cryptarithmetic. Data were analyzed using t tests and ANOVA's. Performance on some problems was influenced by partner status, and respondents' performance varied across the problem set. Results are discussed in terms of cognition and information processing theory. Applications are made to lifespan development and to clinical problems.

The overall problem to be explored is that of processing styles and everyday problem solving. My earlier work has pointed to the importance of formal and postformal logical abilities, experience with social interaction and multiple referents, and complex monitoring and problem space creation skills to problem solving (Sinnott, 1981, 1982, 1983, 1984,and Cavanaugh, et al 1984 in press). Those able to solve illstructured problems seem to use postformal relativistic cognitive operations developed through experience with other thinkers and multiple viewpoints, and do this by means of additional monitoring levels and creation of larger problem spaces in which to "work." They also manifest different strategies from nonsolvers. When problems are seen as illstructured, the solution more often involves an exploration of the "space" of the problem rather than a direct movement from start to goal. This difference in strategies and perceptions of problems has implications for the process and outcome of many illstructured real life problem situations, even those encountered by clinicians in the problem solving of their patients. For example the person resolutely working toward solution of what they see as a clear goal (wellstructured problem) often misses the real problem in their life and continues to do so until they recast the problem as illstructured and explore more of the problem space. So the problem of "Johnny as misbehaving kid so make him better" may not be solved until the parents forget (temporarily) about making Johnny better and explore the reasons behind his behavior and find a new goal such as making the <u>family</u> function better.

Factors not yet explored were the effect of working with a partner on solution of a problem, the effect of the skill level of the partners, and the effect (on style and performance) of the degree of "illstructuredness" on "everydayness"

of the logical problem. Earlier studies (eg. Goldman, 1965, Laughlin et al, 1975) suggested these be examined. These questions were to be the focus of this project. A subsequent lack of volunteers with poor Piagetian logical problem solving skills narrowed the focus of this project since all partners were judged to possess a high level of logical problem solving skills (see Method section for screening procedures) and partners could only be paired consistently. The two dimensions to receive greatest attention in this project, then, became structuredness of the problem and partner status, that is, whether one worked alone or with a partner having similar skills.

Illstructured and wellstructured problems.

In two recent articles (Sweller, 1983; Sweller & Levine, 1982) Sweller discussed the impact of changes in goal specificity on strategies employed on a problem. For a problem high in goal specificity, means-end analyses were the strategies of choice. Little learning of general transferable solutions took place, and processing was more "top down." For a problem low in goal specificity, hypothesis testing was the more usual strategy. Learning was more likely to occur, history-cued rule induction was likely to take place, and "bottom-up" processing was more likely.

A problem also may be seen as either a puzzle (which has a structured goal, an optimal solution path, a single solution for which an algorithm exists, and which utilizes a Lockean inquiry system) or an illstructured problem (to which there is no unequivocal single solution, little certainty about the theoretical assumptions which fit the problem, and which utilizes a Kantian or a dialectical inquiry system) (Churchman, 1971). A respondent's perception as to whether a problem is a puzzle or a less structured problem is part of his/her decision

concerning goal clarity. Developmental differences in assumptions about the nature of knowable reality (e.g., "objective reality is knowable") influence the possibility that a person can consider that a problem is a one-goal puzzle or is a problem that has potential for several goals (Toulmin, 1958). Problems seen as having several potential solutions are frequently dealt with by satisficing (choosing the "good enough" answer) rather than maximizing strategies (Howard, 1983). These everyday problems were judged to be hybrid problems, potentially treated either way or both ways by respondents. Respondent decisions about the nature of the problem were likely to be a systematic source of variation in the strategies employed.

Problem Solving - Individual and non-individual (partner status)

Considerable research has been done on group vs individual problem solving, although the term problem solving in that literature can be anything from brainstorming and role playing to logical problem solving to strategic decision making in corporations or the military (Hoffman, 1965; Lindsey and Aronson, 1978). No studies of this type have been done on Piagetian or maze problems. Looking at those studies of problem solving using logical or arithmetic problems, studies have focused on partner status, ability levels, and speed and efficiency of solution. Sometimes groups solved more twenty questions problems and solved twenty questions, water jar, and arithmetic problems faster than individuals did (Davis, 1969; Taylor and Faust, 1952). High ability respondents gain less from group membership than low ability respondents do using Wonderlic Test problems(Goldman, 1965). But 2-person groups took longer to solve concept attainment problems although they required fewer choices to solution and used a focusing strategy more (Laughlin, 1965; Laughlin, McGlynn, Anderson & Jacobson,

1968). Performance on these problems, then, was not consistently influenced by partner status. This left no clear prediction for the effect of partner status on performance on the problems used in this study.

To answer these questions about the effects of goal clarity and partner status, singles and dyads were tested with five logical, one philosophical, and two maze problems. It was hypothesized that goal clarity would be positively associated with performance and that partner status would have some effect on performance. It was also hypothesized that problems involving everyday and interpersonal components would elicit fewer "passing" performances and different styles from the other problems.

Method

Subjects

Students were recruited from Psychology classes at Towson State University, Baltimore. Of 35 recruits, 10 men and 25 women participated in the study. The nonparticipants either dropped out after the first test session (two persons), could not be matched for personality, or scored below 95 on the Ammons test. Subjects were between the ages of 19 and 45 with 92% of the subjects between 19 and 26.

Tests

Respondents were tested in the test rooms of the Psychology Building at Towson State University. They were administered: a short form verbal IQ test (Ammons Quick Test, Ammons & Ammons, 1962); a Piagetian combinational formal logical problem (Inhelder & Piaget, 1958; Sinnott, 1984); the Myers-Briggs Type Indicator test of personality (Myers, 1975); two finger mazes ("with goal" and "goal-free", pictured in Figures 1 and 2); two everyday Piagetian formal logical

problem (Sinnott, 1984); a subset of problems from the Advanced Raven Progressive Matrices Test (Raven, 1965); a cryptarithmetic problem (Newell & Simon, 1972); and the request to solve the problem of "what constitutes the good life?" (Armon, 1984). Tests represented more or less structured problems in Churchman's (1971) terms. The first three tests were screening devices; the combinational problem also provided an initial heuristic for use on later problems. Screening took one half to one hour; testing took one to two hours. Well structured problems were ABC, Maze 1, D & G, Raven; Maze 2 was illstructured but abstract; the remainder were illstructured and everyday, increasingly so in this order: Camp, Bedroom and Power, Goodlife.

The first and the second mazes (Figures 1 and 2) were actually the same finger maze, rotated, with different starting and goal locations. Therefore it was possible to be aware of the overall nature of Maze 2 after exploring Maze 1. Subjects who learned Maze 1 by learning a series of turns would have the double disadvantage of lack of goal and poorer knowledge of the overall maze. Maze 1 had nine turns in a LLLRRLRLL pattern; Maze 2 had ten turns and a LLLRRRLRLL pattern. The goal in Maze 1 was at the lower right, and the start point at the upper right. In Maze 2 the goal (unknown to respondents) was in the lower left, and the start once again in the upper right.

Procedures

Subjects were recruited, signed a consent form, and were screened in test session one. Remaining subjects were assigned to work as singles (n=15; 4 males) or dyads (n dyads=10; 3 male dyads). Dyads were matched on the Introversion/Extraversion and Intuitive/Sensing dimensions of the Myers-Briggs, and by sex. Characteristics of singles were matched to characteristics of

dyads. All subjects demonstrated an ordered structure for reaching an answer to the screening combinations problem, which set up a heuristic for later problems. Since all subjects were similar in competence on this problem, one original goal of the study (which was to use subject competence as another independent variable) was abandoned, at least until later recruitment and screening, after the grant period.

The second session was the same for singles and dyads. The session began with the finger maze in which respondents knew location of a goal. Respondents took this test blindfolded, timed. During this test and every other in the second session they were requested to think aloud and to say whatever was going through their minds. These thoughts were recorded on tape. The first maze was followed by the paper and pencil problems, worked untimed in a private test cubicle. The last problem was a second finger maze in which respondents did not know the location of the goal. Respondents again were blindfolded and timed for Maze 2.

Respondents were offered information on general or personal results of the tests. Most received class credit points for participation.

Data reduction

Thinking aloud data were transcribed for later analysis of attention and individual styles of problem solving, as well as for use in model building. Paths taken on the mazes were reproduced graphically for later (i.e., beyond grant period) analyses of mapping vs associative strategies. Maze times in seconds were the index of maze performance. Pass/fail scores were given for solution to each and every other problem except the Raven and "good life" problems. The "good life" problem responses were subjected to content analyses of

quality (Kerlinger, 1971)(which will extend beyond the grant period.) Raven performance was the total number of questions answered correctly (0-10).

Results

Descriptive statistics were calculated first. T tests for independent groups were performed to examine possible sex effects on performance. Then t tests for matched groups were used to test the hypothesis that single/cooperative status influenced performance on any of the problems. Repeated measures ANOVA's (2x2) were performed to compare performance on the two mazes in order to test the hypothesis that single/cooperative status and goal clarity jointly influence performance and to obtain evidence for the type of cognitive process (associations, mapping, or both) respondents used. (These results will be buttrussed by the TA and maze path analyses to be completed beyond the grant period.) Repeated measures ANOVA's (4x2) were also performed to test the effects of degree of illstructuredness on logical problem solving performance. It was hypothesized that if subjects created mental maps they would perform better on Maze 2 since the same overall map was pertinent; if they created associations and could not shift, they would perform better on Maze 1 since the pattern of turns on 1 interfered with that on 2; if they could shift strategies between mapping and associations, performance on Maze 1 and Maze 2 would be equivalent. Exactly what they were doing would be apparent from TA analyses. Effects of consistency of partners' learning styles would also become clear after TA analyses.

A descriptive analysis of success on the problems appears in Table 1 by sex and single/coop status. Some problems were more difficult than others, overall, when percentage passing or average score are considered. In order of

difficulty was Raven (easiest), Camp, Power, and (hardest) D+G or Bedroom. Rank of difficulty did not differ significantly by sex or group. No sex differences were found significant by t tests, and data were collapsed across sex. Results of t tests for effects of single/coop status appear in Table 2. Singles usually performed faster on mazes but passed other problems less often than dyads did, with differences for Maze 1, Camp, and Raven being significant.

Insert Tables 1 and 2 about here

Repeated measures 2x2 ANOVA's to test effects of goal clarity and partner status were performed and results were as follows: F maze (1, 23) = 0.01, NS; F partner status (1, 23) = 5.21, p .032; F interaction (1, 23) = 1.31, NS. Mean time for singles was 146 seconds and mean time for dyads was 258 seconds in this analyses. Non-significant mean time differences between Mazes 1 and 2 supported the hypothesis that respondents could shift strategies between mapping and associations. If they indeed did so, this should be evident in their TA protocols when these are analyzed later. When respondents' performance styles across problems are analyzed later, the possible effects of these style differences can be examined in the variety of illstructured and wellstructured problems.

Repeated measures 4x2 ANOVA's to test the effects of problem type (Bedroom, Camp, Power, D+G problems only) and partner status were also performed. Only the problem type effects were significant: F partner status (1, 24) = 2.05, NS, F problems (3, 72) = 29.46, p<.000; F interaction (3,

72)=2.14, NS. The comparative difficulty of the problems is clear from Table 1. For the logical problems based on Piaget's formal operations, the more social/interpersonal and the less abstract the problem context, the less likely respondents were to "pass" in logical terms. This does not mean that respondents did not have logical abilities, only that they defined the problem differently and then appeared to give wrong answers (see Sinnott, 1984 for additional discussion of this point). TA analyses to be completed after grant period will provide models for the sort of process they were really using.

Discussion

The hypothesis of this study that goal clarity would be associated with better performance was supported among the logical problems but not for the maze problems, although Maze 2 did take longer, as predicted. This suggested that respondents could use both associative strategies and mental maps on the mazes. The hypothesis that partner status would effect performance was supported for the mazes and the Camp and Raven problems. The hypothesis that Piagetian logical problems with interpersonal/everyday contexts would appear more difficult the more interpersonal/everyday and the less abstract the context (because that context leads to the problem being considered "illstructured") was also supported. Hypotheses concerning style of problem solving were to be tested by TA analyses and analyses of paths. These will be done after this grant period and will shed light on the actual thinking processes of our subjects.

Concerning goal clarity, the results offered mixed support for the ideas of Churchman (1971) and Sweller (1983), discussed above, in so far as maze problems are concerned. Results did support those views and those of Sinnott

(1984) in the domain of formal operational logical problems. On the mazes, it may have been that too much transfer of learning occurred between Mazes 1 and 2.

Concerning partner status, respondents in dyads took longer to solve the mazes, but more often solved correctly on Camp and Raven. So responses to the mazes were in accord with the results of Laughlin (1965; 1968) on concept attainment problems and Taylor & Faust (1952) on Twenty Questions, water jar, and arithmetic problems. Responses to the Piagetian problems were in accord with results of Taylor & Faust (1952) who found groups solving more problems than individuals.

Why weren't all problems subject to these effects? These were all high ability Ss, and perhaps, as Goldman (1965) found, high ability respondents gained less from group membership. But too few respondents solved D+G or Bedroom correctly to obtain effects on those difficult problems, and results for the remaining problem, Power, were in the direction of those for Camp and Raven. So there was a consistent picture emerging after all.

It can provisionally be hypothesized, then, that the problems used in this study were processed as if they were concept attainment problems and illstructured problems. Further studies may be based on this assumption...which will, hopefully, be supported by analyses of TA reports. It can further be supposed that presence of a partner increases time to solution on Maze and Piagetian problems but also increases accuracy of solution on these illstructured logical problems since so many respondents redefined the logical problems for themselves or in accord with a partner (Sinnott, 1983, 1984) as predicted for mature adults. Postformal operations (Sinnott, 1984) are

especially possible here since all these respondents had passed a formal problem as part of the screening procedure and therefore were formal operational. Illstructured problems done with a partner seem to be a good context for examination of postformal operations in future work.

TA analyses (to follow) will be able to show just how respondents make decisions about a goal in an illstructured problem and how they manage to merge their own sets of operations with those of a partner. Such analyses and knowledge will permit better interventions in real life problem solving such as that in work or clinical settings.

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Table 1

Success on Problems, by Sex and Single/Coop Status

Problem	Women n=19	Men n=7	Single n=16	Coop n=10 pairs	All Ss
Mean seconds to complete Maze 1	172.47	226.00	141.87	258.90*	186.88
Mean seconds to complete Maze 2	193.16	200.28	179.06	219.30	195.16
Camp-% pass	78.9%	71.4%	62.5%	100%*	76.9%
Bedroom-% pass	5.3%	0%	6.3%	0%	3.8%
Power-% pass	31.6%	0%	18.8%	30.0%	23.1%
D+G-% pass	5.3%	0%	6.3%	0%	3.8%
Raven-mean correct	9.26	9.85	9.12	9.90*	9.42

* differ significantly, see Table 2

Table 2

Results of t Tests for Effects of Single/Coop Status

Problem	t Value*	df	2-tail probability
Maze 1	-2.46	24	.02
Maze 2	-0.94	23	.35
Camp	-2.35	24	.02
Bedroom	0.78	24	.44
Power	-0.64	24	.52
D+G	-0.34	24	.74
Raven	-1.76	24	.09**

*Single minus coop

**Separate variance estimate gives a significance of .04

Figure 1

Maze 1

Figure 2

Maze 2